

WHAT IS CLAIMED IS:

1. A method for locating a regularly configured object within a digital image, said method comprising the steps of:
 - computing a plurality of primary rotated integral images of said digital image, each said primary rotated integral image having a different in-plane rotation;
 - deriving from each of said primary rotated integral images a set of secondary rotated integral images having further in-plane rotations relative to the respective said primary rotated integral image;
 - defining a window within said digital image and corresponding windows of said rotated integral images;
 - extracting the values of convolution sums of a predetermined set of feature boxes within said window, in each of said rotated integral images;
 - reducing dimensionality of said convolution sums to provide a set of reduced sums;
 - applying a probability model to said reduced sums to provide a best estimated derotated image of said window.
2. The method of claim 1 wherein said further in-plane rotations are at 90 degrees, 180 degrees, and 270 degrees relative to the respective said primary rotated integral image.
3. The method of claim 1 further comprising, following said applying, detecting the regularly configured object within said derotated image.
4. A method for locating one or more regularly configured objects within a digital image, said method comprising the steps of:
 - computing a plurality of rotated integral images of said digital image, each said rotated integral image having a different in-plane rotation;
 - defining a plurality of windows within said digital image and corresponding pluralities of windows of said rotated integral images;

extracting the values of convolution sums of a predetermined set of feature boxes within each said window, in each of said rotated integral images;
reducing dimensionality of said convolution sums from each of said windows, to provide a respective set of reduced sums;
applying a probability model to each of said sets of reduced sums to provide a best estimated derotated subimage of each of said windows.

5. The method of claim 4 wherein said further in-plane rotations are at 90 degrees, 180 degrees, and 270 degrees relative to the respective said primary rotated integral image.

6. The method of claim 4 applying a detection algorithm to each of said derotated subimages.

7. The method of claim 4 wherein said reducing further comprises applying a principle components analysis to said convolution sums.

8. The method of claim 4 wherein said probability model is selected from the group consisting of Gaussian and modified Gaussian probability models.

9. The method of claim 8 wherein said probability model has the form:

$$\hat{P}(\mathbf{x} | \Omega) = \left[\frac{\exp\left(-\frac{1}{2} \sum_{i=1}^d \frac{y_i^2}{\lambda_i}\right)}{2\pi^{\frac{d}{2}} \left(\prod_{i=1}^d \lambda_i\right)^{\frac{1}{2}}} \right] \left[\frac{\exp\left(-\frac{\varepsilon^2(\mathbf{x})}{2\rho}\right)}{(2\pi\rho)^{(N-d)/2}} \right]$$

10. The method of claim 8 wherein said probability model has the form:

$$P(\mathbf{x} | j) = \frac{\exp(-\frac{1}{2} \sum_{i=1}^d \frac{y_i^2}{\lambda_i^j})}{2\pi^{\frac{n}{2}} (\prod_{i=1}^d \lambda_i^j)^{\frac{1}{2}}}$$

11. The method of claim 4 wherein said defining further comprises exhaustively searching said rotated digital images at all locations and scales.

12. The method of claim 4 wherein said feature boxes are arranged in first and second horizontal rows, each row having two outer feature boxes, each said outer feature box being longer horizontally than vertically, each said row having a single inner feature box disposed between respective said outer feature boxes.

13. A computer program product for locating a regularly configured object within a digital image, the computer program product comprising computer readable storage medium having a computer program stored thereon for performing the steps of:

computing a plurality of rotated integral images of said digital image, each said rotated integral image having a different in-plane rotation;

defining a plurality of windows within said digital image and corresponding pluralities of windows of said rotated integral images;

extracting the values of convolution sums of a predetermined set of feature boxes within each said window, in each of said rotated integral images;

reducing dimensionality of said convolution sums from each of said windows, to provide a respective set of reduced sums;

applying a probability model to each of said sets of reduced sums to provide a best estimated derotated subimage of each of said windows.

14. A system, which locates a regularly configured object within a digital image, said system comprising:

a computational unit receiving a digital image from an image source, said computational unit including:

- an integral image module computing one or more primary rotated integral images of said digital image, each primary rotated integral image having a different rotation relative to an initial position defined by the in-plane rotational position of the digital image;
- a derivation module deriving a set of secondary rotated integral images from each of the primary rotated integral images;
- a window module defining one or more windows within the primary integral images and corresponding windows in said secondary rotated integral images;
- an image measurement module extracting one or more sets of representative image measurements from each of said windows and summarizes said measurements as one or more corresponding numerical data vectors;
- a dimensionality reduction module performing a mathematical transformation on the numerical data vectors, resulting in transformed numerical data vectors that have an increased stability;
- a probability module evaluating a probability density model, using said transformed numerical data vectors, to determine a probability of a face being present.

15. The system of claim 14 further comprising a de-rotation module digitally rotating an extracted image window produced by said probability model by an amount to exactly compensate for the most probable face orientation, producing a derotated image.

16. The system of claim 14 further comprising an object identification module detecting the regularly configured object within said derotated image.

17. The system of claim 14 wherein said regularly configured object is a member of the class of human faces.

18. The system of claim 14 wherein said window module exhaustively searches said rotated digital images at all locations and scales.

19. The system of claim 14 wherein said image measurement module extracts values of convolution sums of a predetermined set of feature boxes within each said window, in each of said rotated integral images.